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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H02K 1/16, 3/46 | A1

(11) International Publication Number: WO 95/12912

(43) International Publication Date: 11 May 1995 (11.05.95)

(21) International Application Number: PCT/SE94/01026

(22) International Filing Date: 1 November 1994 (01.11.94)

(30) Priority Data:

9303602-8	1 November 1993 (01.11.93)	SE
9400076-7	10 January 1994 (10.01.94)	SE
9401524-5	3 May 1994 (03.05.94)	SE

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(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ).

Published

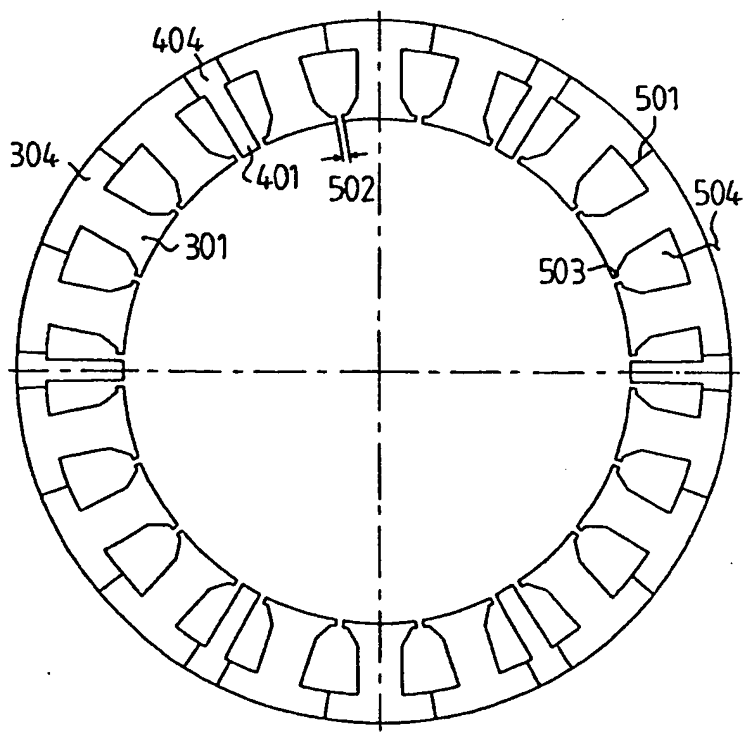
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: AN ELECTRIC MOTOR AND ITS FABRICATION

(57) Abstract

In a brushless electric motor/generator there are poles (301, 401) which are separate mechanical parts and are assembled to form a stator. The poles (301, 401) comprises outer portions (304, 404) projecting in a circumferential direction from the main leg of the poles. These outer portions (304, 404) are engaged with each other, thus forming a magnetic yoke carrying magnetic flux between the poles. This permits an easy winding of the separate poles and a good support thereof by an outer ring.



EV 327050180 US

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AN ELECTRIC MOTOR AND ITS FABRICATION

Technical Field

The invention is concerned with methods of designing and producing stators for in particular brushless motors/generators and the motor/generator stators and motors/generators thus produced.

Background of the invention and prior art

To obtain highly efficient electrical motors some requirements are commonly understood. The design should give short amounts of current conducting winding material that is outside the stator parts that are highly permeable for magnetic flux. The design should also permit much current conducting winding material in the winding slots. Further, the thermal path between the current conducting winding material and the intermediate heat sink like the outer housing of the motor should be good enough to keep the winding temperature at an acceptable level at power losses that the outer casing can dissipate at acceptable surface temperatures. The design should also give stators that are mechanically robust.

Brushless DC motors have their windings in the stator. Most stators are three-phase and have stator windings similar to that of a three phase induction motor.

Almost all electric motors with alternating current stator windings (including brushless DC motors and induction motors) in sizes up to some 10 kW have their stators made of lamination sheets that cover the whole circumference of the motor. These punched laminations are assembled together by welding or other means to form a rigid hollow cylinder. Thereafter the winding slots are insulated. The windings are wound outside the stator and thereafter inserted in the slots. This method does give two disadvantages.

The first disadvantage is that it does not permit a very orderly arrangement of the winding wires in the winding slots. In order to obtain a very high utilization of a winding slot in a stator, the wires should run parallel to each other. For wires of circular cross-section, a hexagonal arrangement where each wire is surrounded by six other wires is normally the most efficient arrangement.

The second disadvantage is that a prewound winding coil must

have a considerable surplus length to permit insertion in a stator winding slot. In the case of overlapping polyphase windings, a certain excess length is required to permit insertion of a winding without being locked by the other phases. In the case of salient poles, a certain excess length is required to as the winding must be heeled over the pole tooth head portions. This results in unnecessary current conducting winding material that is outside the stator parts that are highly permeable for magnetic flux.

Figure 1 illustrates a rolled-out view of a conventional stator with overlapping phases as seen from the rotor.

The arc 101 shows one part of the current conducting winding 104 that is not inserted inside the flux permeable part of the stator, while 103 shows a part that is inserted inside the flux permeable part of the stator. 102 shows the stator pole as seen from the rotor.

Figure 2 illustrates a rolled-out view of a conventional stator as seen from the rotor of a brushless motor as disclosed in the published International patent application WO-A1 92/06530. These motors, and motors as disclosed in the published International patent application WO-A1 93/15547, have windings consisting of groups of stator poles 201, each having a simple coils 202 around it. In the case of motors as disclosed in the cited International patent application WO-A1 92/06530, the gaps between different pole groups are bridged by balancing poles 203.

A common problem in the winding of motor stators is to reduce the amounts of current conducting winding material that is outside the flux high permeable stator parts. This material is shown separately as 101 and 204 in figures 1 and 2 respectively.

The US patent 3,792,299 discloses a stator for an electric motor comprising an outer annual yoke and a plurality of radially directed stator teeth. In another embodiment (figure 7) in the same patent, the yoke is assembled of a plurality of yoke parts. In both cases, the flux carrying parts of the stator consists of separately punched stator teeth. The winding of the stator is made by first arranging the stator teeth so that during the winding procedure, the slot spaces for the stator winding will be open radially outwards. This permits a winding with far less surplus length as there is more freedom in adjusting the coils of

the different phases of the winding to each other during assembly. After the winding procedure these openings are closed by a stator ring or yoke, whereafter moulding together of winding, stator teeth and stator yoke is carried out by means of lacquer or moulding compound to a rigidly assembled stator unit.

The US patent 3,353,046 discloses a stator produced from a cog-wheel shaped stator teeth set. After winding, impregnation with a thermosetting resin and baking, the resulting solid body is ground down to an outer diameter that fits an outer, cylinder shaped yoke ring. After that the yoke cylinder is assembled and fixed by another impregnation and baking process, the common base of all the stator teeth is ground down from the inside so that the base disappears and the required gaps between each stator tooth appears.

The US patents 2,459,673, 2,517,105, 2,654,037, 2,655,613, 2,687,483, 2,691,113, 2,745,031, 3,449,607, 3,549,926, 3,612,930, 3,740,600, 4,246,505, 4,433,262 and 4,816,710 and the published International patent application WO-A1 92/10021 disclose various ways to design electrical machines with yokeless separate salient poles which are assembled on a stator or rotor yoke. Most or all of these designs have solid (not laminated) poles and/or yokes and seem to be designed exclusively for poles with DC current coils to be used as stator field magnets (interacting with laminated rotors in mechanically commutated DC machines) or rotor poles for synchronous machines (interacting with laminated three-phase stators).

The published International patent application WO-A1 92/03870 discloses a design where laminated salient poles can be assembled into a laminated stator yoke. The assembled stator shape corresponds to stators commonly as field in a mechanically commutated DC machine).

<u>Summary</u>

A purpose of the invention is to provide a brushless motor stator that permits much current conducting winding material in the winding slots.

Another purpose of the invention is to provide a brushless motor stator that give short amounts of current conducting winding material that is outside the stator parts that are highly permeable for magnetic flux.

Another purpose of the invention is to provide a brushless motor stator that permits a low thermal impedance to the intermediate heat sink.

Another purpose of the invention is to provide a brushless motor stator that permits automated, space efficient winding of the winding wire.

Another purpose of the invention is to provide a brushless motor stator that permits the use of oriented stator material.

Another purpose of the invention is to provide a brushless motor stator that permits efficient use of the rolled material used for the laminated stator, thus permitting the use of higher cost high quality rolled material.

Another purpose of the invention is to provide a brushless motor stator that permits small interpole airgaps between the stator teeth close to the stator to rotor air gap, and that permits this also in case of large diameter winding wire.

Another purpose of the invention is to provide a brushless motor stator that has a low weight.

Another purpose of the invention is to provide a brushless motor stator where little axial space is required in front etch and rear of the magnetically permeable part of the stator.

Another purpose of the invention is to provide a brushless motor stator that efficiently can be cooled by forced air ventilation.

The problems discussed above are solved by and the above mentioned purposes are achieved by the invention, the characteristics of which appear from the appended claims.

The invention thus permits the design and production of stators for electrical machines with alternating current salient stator poles that have very short amounts of current conducting winding material that is outside the flux high permeable stator parts, that permits much current conducting winding material in the winding slots, that have an excellent thermal path between the current conducting winding material and the intermediate heat sink like the outer housing of the motor. It also gives very high utilization of the rolled sheet material used for the stator laminations and permits the use of anisotropic magnetic materials.

The stator is thus built of separate parts that acts as

combined single poles and yoke arch segments. Each of these segments constitutes a part of the whole circumference of the yoke. Generally there thus in an electric motor/generator poles which are separate parts and are assembled to form a stator. The poles comprise outer portions projecting in a circumferential direction from the main leg of the poles. These outer portions are engaged with each other, thus forming a magnetic yoke carrying magnetic flux between the poles.

Brief description of the drawings

The invention may be better understood from the following detailed description when read with reference to the drawings in which:

Figure 1 schematically shows a common stator winding with overlapping phases as seen from the rotor.

Figure 2 schematically shows a prior stator winding without overlapping phases as seen from the rotor.

Figure 3 shows a side view of a stator pole that constitutes a coil carrying stator arch segment in an electric motor.

Figure 4 shows a side view a stator pole of the electric motor that acts as an unwound flux balancing stator arch segment.

Figure 5 shows an axial view of the flux carrying parts of a complete stator.

Figures 6a and 6b show an assembled stator in cross-sectional views in an axial plane and a radial plane respectively.

Figure 7 shows a punch layout of the stator parts according to figure 3.

Figure 8 shows a perspective view, as seen obliquely from the rotor, of three stator poles according to figure 3 and one pole according to figure 4 together with six devices acting as coil end winding supports and pole gap fixtures.

Figure 9 shows a section along a radial plan of a winded stator pole illustrating how devices according to figure 8 acts as a coil winding support and pole gap fixture.

Figures 10a and 10b show an assembled stator using coil end winding support and pole gap fixtures according to figure 8 in axial and radial cross-sectional views respectively.

Figure 11 shows a side view of a portion of the stator of a linear motor using anisotropic materials.

Figures 12a and 12 show an assembled stator in axial and

radial sections respectively.

Figure 13 shows a section along a tangential plane through a wound stator pole with winding support fixtures according to figure 8.

Figure 14 shows an axial view of a coil end winding support and pole gap fixtures according to figure 8 designed to permit an odd number of winding layers.

Figure 15 shows an axial view of a stator having interlocking surfaces on the stator parts.

Detailed description

The invention will now be described using exemplary embodiments suited to electrical machines like those disclosed in the cited WO-A1 92/06530 and WO-A1 93/15547. The description is only given in explanatory and clarifying purposes and is not intended to limit the invention.

Figure 3 shows an axial view of a stator pole that constitutes an arch segment of a stator of an electric motor. The pole 301 has an outer, basically circular-cylindrical segment side or surface 302 that in the assembled motor faces the motor casing, an opposite and concentric, inner, basically circular-cylindrical segment side or surface 303 that in the assembled motor faces the rotor, two basically radially oriented sides 304 and 305 that in the assembled motor faces the adjoining stator parts, and a centre pole leg 306 intended to carry a winding. It is obvious that the pole can be very easily wound with a very efficient winding with much current conducting winding material in the winding slots. As the pole leg 306 being a separate part is freely accessible from all sides, automatic winding machines can wind a winding thereon with optimal stacking of the wire layers. In some cases, rectangular or other space optimising wire cross-sections can be used. The shape of the pole is adapted for isotropic magnetic materials in the stator. As described in the cited International patent application WO-A1 92/06530, the peak flux entering from the rotor side 303 will be divided into two basically equal parts that leaves the pole through the sides 304 and 305 respectively. Assuming that the flux density in the sides 304 and 305 can be accepted to have the same or somewhat lower value as in the pole leg 306, the added length of sides 304 and 305 should be equal or somewhat longer than the width of pole leg

306.

Figure 4 shows an axial view of another stator pole that constitutes a stator arch segment. The pole of figure 4 is not intended to carry a winding and is intended to act as a flux balancing pole as described in International patent applications PCT WO 92/06530. The pole 401 has a basically circular-cylindrical outer segment side 402 that in the assembled motor faces outwards, towards the motor casing, a concentric, inner, basically circular-cylindrical segment side 403 that in the assembled motor faces the rotor and two basically radially oriented sides 404 and 405 that in the assembled motor faces the adjoining stator.

Each stator arch segment as 301 and 401 can be built in the conventional way of electrical motor fabrication. The most common way would be to use laminations of electric steel. The laminations can be kept together using glue, welding on the outer periphery 302 and 402 receptively, snapped together with the previous lamination sheet as is sometimes done to keep the laminations of transformer E-shaped cores together, etc. Other materials like iron powder or ferrite parts are also possible, the stator arch segments then being solid.

Figure 5 shows an axial view of the flux carrying parts of a complete stator comprising the elements shown in figures 3 and 4. The windings are not shown. During assembly, the stator parts should be kept together to reduce the air gap in the joints like 501. They can for example be kept together by magnetic attraction from a centre piece (not shown) that arranges an inward pressure on the parts towards the centre, the axis of the motor. To avoid large eddy currents between meeting laminated packs in the joints 501, a thin insulating foil 504 of for example polyimide like Kevlar can be inserted in each joint. The small pole to pole air gap 502 in a lateral or circumferential direction has two basically parallel short sides 503 as shown in figure 3 and 5. The shape of the gap with two parallel sides is advantageous for the ability of the distance keeping filler material like a thermal encapsulant to withstand tangential forces which during motor operation will act on the teeth. The motor torque corresponds to forces tangential to the surface 303. Such forces will be perpendicular to the small surfaces 503 that are pressing

on the distance keeping filler material, and these forces will therefore act as a pressure on the distance keeping filler material.

Figure 6a shows an axial section of an assembled stator and figure 6b shows a radial section along the line B-B of figure 6a of the assembled stator, these figures also illustrating another front bell 601. Figures 6a and 6b do not show a complete stator system; the rear bell is not shown.

The front bell 601 has a main body extending in a radial plane and an integrated annular member or cylindrical ring projecting therefrom. The ring member comprises at its inner surface a step 602 against which the stator parts like 301 are inserted in an axial direction. The coil winding is seen as two parts 603 protruding from the pole 301.

Another step 605 at the inner side of the ring member of the front bell 601, at the open side of the member, act as a stop for a washer 606. The inner diameter of the washer is slightly larger than the inner diameter of the stator parts 301 and 401. During assembly, a tool (not shown) keeps the stator inner surface circular and in the correct position relative to the front bell 601. The cylindrical outer surface of the tool engages the inner surface 607 of the front bell main body. In this way the front bell and the cylindrical outer surface of the tool creates a pot, which under vacuum is filled and impregnated with a thermally conductive and hard encapsulant like Aremco Ceramacast 645 shown as shaded area 608 in figure 6.

The purpose of the ring 606 is to provide a thermal path from the winding part 604 to the intermediate heat sink in the shape of the front bell 601. Cut-outs 610 in the ring 606 are used to give an exit to winding connections 611.

The high amount of conductive winding material in the winding slots and the short wasted winding length 204 gives a low amount of dissipated heat for a given number of ampere turns in the stator winding slot. This low heat amount has a very short path to the nearest metallic heat conductor like pole 301, front bell 601 or rear heat sink ring or washer 606, and this short distance is filled with a thermally highly conductive encapsulant 608. Combined, this gives a motor that can accept many ampere turns in the stator winding for a given acceptable temperature of the

winding.

For extreme conditions including high speed operation, requirements of low weight and large variations of temperature, the front bell should be made of a not ferromagnetic material with a thermal expansion similar to the stator lamination. Front bells of alloys like Inconel X750 or titanium fits very well to the expansion coefficients of stators of iron or iron-nickel laminations and encapsulants like Aremco Ceramacast 645, all of them having linear thermal expansion around $10x10^{-6}/K$.

For less demanding applications, cast iron housings or bells 601 can be used having a sufficiently thick encapsulant barrier in the area marked 609 to limit the alternating flux leakage from the stator to create large eddy current losses in the housing 601. For many applications, aluminium housings are also possible.

Figure 7 shows how several stator parts or stator laminations according to figure 3 can be punched out from a rolled strip. It is evident that the material losses can be kept very low. The low material losses reduces the penalty of using more expensive materials like alloys containing Nickel or Cobalt. As the main flux path for all stator poles are parallel, anisotropic materials can be used.

Figure 8 shows three stator poles 301 according to figure 3 and one pole 401 according to figure 4 with six devices acting as coil end winding supports and pole gap fixtures. These devices will in the following be called semibobbins. Two semibobbins are put on the top and bottom of each pole 301. Each semibobbin has protruding parts 801, 802, 803 and 804, which secure each semibobbin in the tangential and radial directions relative to the stator pole 301. One purpose of the semibobbins shown in figure 8 is to facilitate the assembly of the total stator system before encapsulation with an encapsulant. Each semibobbin has a part 805 protruding from part 804. The part 805 acts as a distance keeping filler between adjacent stator parts 301 to maintain the inter-pole gap shown as 502 of figure 5. The surface 303 of the stator parts 301 that in the assembled motor faces the rotor are in figure 8 shown with the parts 805 as distance maintaining elements. Between any adjacent poles 301 there are two distance elements 805. Between adjacent poles 401 and 301 of different kinds there is only one distance element 805. The

remaining end of the inter-pole gap between adjacent poles 401 and 301 is maintained by a part 806 protruding from part 801.

The front surface 808 of the six semibobbins will together with the parts 303 and 403 of the stator poles create an almost complete cylindrical surface against the rotor. In figure 8 one sixth of this surface is shown.

The edges 807 of the front surface 808 will support the adjacent stator pole 301 or 401. In the position shown as 809, the central stator pole 301 is supported by the left semibobbin that is mounted on the lower stator pole 301.

The edge shown as 807 would support the stator pole 401 that in a complete rotor would continue the stator in the upper left corner of figure 8. The rear surface 810 is shown as a continuous surface even though it in most embodiments would be equipped with slots or other devices to arrange the entrance and exit of winding wire.

Figure 8 shows one sixth of an unwound stator. In normal production, each pole is wound before the different poles are assembled to make a complete stator.

Figure 9 shows a radial section of a wound stator pole 301. The figure shows a section near the axial side of the pole so that the section passes through the protruding parts 801 to 806. In this embodiment the shape of the winding supporting sides 801 to 804 are designed to accept winding wire of different diameters, and have therefore slopes that are 90 and 60° in relation to the pole axis or an axial central plan through the pole. This permits precision winding of several wire dimensions using winding machines. The winding layers will then be densely packed with the cross-sections of the wire being arranged in a hexagonal order. Also, the front ends of the poles 301 facing the rotor can be designed in a way optimal for the magnetic flux and still the windings can be made in an orderly way.

The radius that the winding has to follow can be seen as 811 in figure 8. This fairly large radius will permit the winding wire to enter the winding slot with the wires basically parallel to the motor axis, thus obtaining the high space utilisation shown in figure 9.

Another advantage of the stator design principle evident from figure 9 is that the wire diameter can be larger than the pole

gap shown as 502 in figure 5.

Figures 10a and 10b show sections of a complete stator of an embodiment using semibobbins.

Figure 10a shows a simplified section parallel to the axis. For clarity, most of the details that are not in the section plane are omitted. The lower end bell is included in the figure for orientation purposes.

Figure 10b shows a simplified section perpendicular to the axis. For clarity, most of the details that are not in the section plane are omitted. The figure shows a section through a level not too near the end of the pole so that the sections does not go through the protruding parts 801 to 806 of the semibobbins.

In the production principle for the embodiment shown, the stator is produced as a complete hollow cylinder unit, that later is assembled with the rotor and the end bells like 1005.

The stator consists of an outer ring 1001, a stiff, thermally conductive encapsulant 1002, unwound poles 401 and wound poles. These poles basically consists of a pole 301, two semibobbins 1003 and winding wire 1004.

The outer ring 1001 could advantageously be made of a not ferromagnetic material with a thermal expansion similar to that of the stator lamination.

The embodiments shown in figure 3 to 10 show rotating motors with inner rotors and outer stators with isotropic stator material. The invention is however applicable also to rotating motors with inside stators and outside rotors, to linear motors and to stators built with anisotropic magnetic materials.

Figure 11 shows a section of part of a linear motor stator using anisotropic stator material and semibobbins specially designed for a certain wire dimension. Only two poles like 1101 are shown. They are mounted on a preferably not ferromagnetic base 1102 and fixed in position by a mechanically rigid, thermally conducting encapsulant 1105 that fills the thin channel 1106. The winding 1103 is kept in place by semibobbins 1104 similar to those shown in figure 8. In the semibobbin of figure 8, the shape of the winding supporting sides 801 to 804 are designed to accept winding wire of different diameters. The semibobbin shown in figure 11 is specially designed for a certain

wire diameter, and has several discrete steps 1107 that fits the wire diameter selected.

Figures 12a and 12b show sections of another embodiment of a hollow cylinder stator unit.

The stator consists of an outer ring 1201 with a step 1202 in the inner cylindrical surface thereof, against which the stator poles will be positioned during assembly. The inner diameter of the ring 1202 facing the poles could in this embodiment advantageously have a radius very close to the outer radius of the ring that consists of the stator poles. The stator poles could then be kept in place by a firm pressing down to the step 1202, by light pressing down to the step 1202 combined with a locking fluid like Loctite or by light pressing down into a preheated ring 1201. The step 1202 also gives a ring with more stable form as the material thickness of the ring below the step 1202 could be considerable. The remaining spaces 1203 and 1204 in the hollow cylinder is then filled with a stiff, thermally conductive encapsulant.

Any force bending the position of any stator pole radially in the centre position would in this case meet balancing forces from the ring 1201 as any rotation of a pole requires a outward displacement of the outer ring 1201, friction/glue shearing forces from the surfaces 1205 where the stator poles are in close distance to each other, forces from the stiff encapsulant in volumes 1203 and 1204 and forces from the pole gap fixtures like 805 in figure 8.

The outer ring 1201 - 1202 could be made of a not ferromagnetic material with a thermal expansion similar to that of the stator lamination. The ring can however for many applications be made of for example aluminium. In such cases the ring can with advantage be given a inside diameter that is slightly lower that the assembled outside diameter of the stator arc segments and be heated to a suitable temperature before assembly. After shrinking, such a ring will create a radially inward pressure against the stator arc segments. As punched parts normally have very small tolerances between batches, the resulting force could be kept within acceptable limits over a wide temperature interval. This radial inward force will act to reduce the gap between the stator arc segments, and will thereby

reduce the magnetic losses in these airgaps. Furthermore, this force will also force the stator arc segments to align precisely, thus acting to reduce the variations of the interpole gap like 502 between the stator teeth.

In some embodiments of the invention, for example some of those which like the one illustrated in figures 12a and 12b create a substantial pressure on the stator arc segments, the interpole gap like 502 will get acceptable tolerances even without the distance keeping parts 805 of the winding supports. This permits a more simple shape of the winding supports.

The embodiment of figures 12a and 12b highlights some of the advantages of the present invention as compared to previous art. For brushless motors and generators with non-overlapping windings, such as those disclosed in the cited International patent applications WO-A1 92/06530 and WO-A1 93/15547, flux entering into one pole tooth will exit through the two adjacent teeth. In a stator as that of figures 12a and 12b, this flux will pass only one air gap, and this air gap kept at a minimum width due to the external pressure of the outer ring 1201. As a contrast, stators as disclosed in the cited US patent 3,353,046 consist of several parts, where the flux must pass two or more air gaps between stator parts, and where there is no low cost way to ensure a large pressure to keep the stator parts together during the hardening of the encapsulants.

The embodiment according to figures 12a and 12b can in some applications be made without the addition of an encapsulant; this can be of interest in cases where the power dissipation is low, where high torque is only used during very short intervals and in applications where cooling with forced air ventilation inside the electric machine is preferred.

A method of assembling a stator as the one illustrated in figures 12a and 12b will now be briefly described. The stator pole parts are produced by stamping or punching and the laminate sheets having a profile as that illustrated in figures 3 and 4 are assembled into poles like 1207 as described in connection with figure 4. Depending on the assembly method, the heat treatment to restore the magnetic properties are made either before or after the assembly to poles.

The poles 1207 are then equipped with two semibobbins 1208

and 1209. The semibobbins can be secured to the poles 1207 by two turns of electric insulation tape. It will both secure the position of the semibobbins to the poles 1207 and ensure a sufficient electric isolation between the winding and the metal pole 1207, also along the only surfaces 1210 where the winding wire is not isolated from the metal pole by the semibobbins.

The poles 1207 are then inserted into an automatic winding machine that winds an orderly, dense winding as illustrated in figures 12a and 12b. The winding entry end is locked by the winding, and the exit end can either be locked by a sharp turn in some wire exit slot (not shown) in the surface 810, see figure 8. Alternatively, a specially treated winding wire can be used that bakes together when the winding machine heats the wire by injecting a high current pulse into the wire.

The wound poles like 1207 made from laminated poles 301 and the unwound poles 1211 similar to the poles 401 are then arranged as illustrated in particular in figure 12b; they can be kept against a center cylinder by magnets in the center cylinder. The outer ring 1201 is then heated to a suitably high temperature and the stator part ring is then pressed down into the ring 1201; in the section of figure 12a the ring is kept static or geometrically fixed and the stator ring is lowered into the hot stator ring. The wires from the poles are then connected to form a Y-connected stator of three phases, each phase containing six stator coils in series.

The stator ring is then inserted into a mould that later is filled by the encapsulant, and the stator is kept in the mould while the encapsulant is solidifying. If required, a light grinding can be made finally to ensure smooth surfaces against the front and end bells.

Figure 13 shows a section through a wound stator pole with two semibobbins. The section is taken through the central part of the stator pole leg 306. The protruding parts like 802 and 803 that fixes the position of the semibobbin are hidden behind the winding 1301 (shown as 809 in figure 8 and as 1004 in figure 10).

The bottom part 1302 of the semibobbin can advantageously be somewhat wider (in the horizontal direction as seen in figure 13) than the centre pole leg 306. This will hide the sharp corners like 1303 from the surface towards the winding wire. Before

winding, the semibobbins and central pole leg can be wound with one or a few turns of high voltage insulation tape. The semibobbins can even have short, thin rims extending a short distance at the sides of the poles where the main body of the semibobbins is not located, these rims thus being located near the corners 1303 and also keeping the semibobbins in a correct position.

As is evident in figure 13, the two semibobbins will permit the advantage of a good wire geometry in the winding slot. The large radius 811 given by the semibobbin will permit the wire to bend smoothly so that the wire is practically parallel to the side of the central pole leg 306 in the winding slot.

Other advantages of having two semibobbins in place of one complete bobbin are evident from figure 13. If a one-part bobbin was to be used, the two extra sides of the bobbin would occupy some of the space now being used for the innermost wire of the winding 1301. If these two extra sides are made thin, they would break if the winding wire tension is high. With the semibobbins described above, the winding can be made using a suitable high tension in the wire. The only consideration of the mechanical strength of the semibobbins is that the wire tension must not deform the massive core of the semibobbin; this limitation is several orders of magnitude larger than the stability of the thin walls of a full bobbin and can normally be neglected.

Figure 14 shows a semibobbin designed to permit an odd number of winding layers; this is accomplished by an entry opening 1401 through the rear bobbin side (corresponding to 810 of figure 8). This leads to a channel 1402 with a depth that is slightly larger than the diameter of the wire. This channel ends with a suitable bend to a exit channel 1403, the depth of which gradually decreases so that the depth is zero when the wire enters the winding slot in the stator.

Figure 15 shows an axial view of a stator, where the previous radial end surfaces of the arc segments are replaced by radially interlocking surfaces. These surfaces act to align the stator yoke segments radially.

While only a few embodiments of the present invention has been shown, it is obvious for those skilled in the art that numerous modifications may be made without departing from the

spirits of the present invention, which should be limited only by the scope of the claims appended hereto.

CLAIMS

1. An electric motor/generator having a stator and a rotor, an annular air gap between the stator and the rotor, said stator comprising an outer annual yoke carrying the magnetic flux between a plurality of radially directed stator teeth, most or all stator teeth having a winding in the form of a coil wound around one single stator tooth, all said stator teeth being produced as mechanically separate parts comprising the stator tooth, **characterized in** that all stator teeth also comprise a segment of the stator yoke.

2. An electric motor/generator according to claim 1, **characterized in** that the stator teeth in the assembled state are fixed in a rigid assembly by an outside ring which presses the stator parts radially inward.

3. An electric motor/generator having a stator and a rotor, an linear air gap between the stator and the moving part, the stator comprising a straight yoke and a plurality of stator teeth extending generally perpendicular to the yoke, most or all stator teeth having a winding in the form of a coil wound around one single stator tooth, **characterized in** that all said stator teeth are produced as mechanically separate parts comprising the stator tooth and a segment of the stator yoke.

4. An electric motor/generator according to one of claims 1 to 3, **characterized in** that the inner ends of the teeth are formed with pointed tooth shoulders wherein adjacent shoulders are closely spaced apart to provide a narrow gap therebetween.

5. An electric motor/generator according to one of claims 1 to 4, **characterized in** that the stator teeth and the wiring in the assembled state are fixed in a rigid assembly with a thermally conductive and electrically insulating moulding compound.

6. An electric motor/generator according to one of claims 1 to 5, **characterized in** that the coil winding wire during and after winding is mechanically kept in place in the axial ends of the stator poles by devices having parts facing and/or embracing partially the stator pole tooth thereby locating the device relative to the stator tooth, other parts of the devices being adapted to locate the wire relative to the stator pole in a way that facilities the winding of coils is such a way that the wires

of the coils will run parallel to the axial direction of the stator poles along the axial length of the stator poles.

7. An electric motor/generator stator according to one of claims 1 to 5, **characterized in** that the coil winding wire during and after winding is mechanically kept in place in the axial ends of the stator poles by devices having parts facing the stator pole tooth thereby locating the device relative to the stator tooth and other parts of the said devices being suited to locate the wire relative to the stator pole in a way that facilities the winding of coils with efficiently packed wires, in particular having the wire centres stacked in a 60-60-60 degree triangular pattern in the case of circular section wires.

8. An electric motor/generator according to one of claim 6 or 7, **characterized in** that a coil winding locating device includes other parts suited to locate the stator poles relative to each other, especially to ensure that the pointed tooth shoulders at the inner ends of said teeth during and in some embodiments also after the process of moulding will be located evenly spaced apart to provide a narrow gap between adjacent teeth that is approximately equal for all teeth of the same stator.

9. An electric motor/generator according to one of claims 1 to 8, **characterized in** that the pointed shoulder parts of the stator poles close to the rotor are formed in such a way that the surfaces constituting the air gap between adjacent stator poles are basically parallel.

10. An electric motor/generator according to one of claims 1, 2 or 3 to 9, **characterized in** that the stator poles during and after the moulding are kept in position by an annular outer ring being located outside the stator poles.

11. An electric motor/generator according to one of claims 1, 2 or 3 to 9, **characterized in** that the stator parts are kept in position by an annular outer ring being located outside the stator poles and applying a pressure against the stator parts.

12. An electric motor/generator according to one of claim 10 or 11, **characterized in** that the annular outer ring is made of a not ferromagnetic material with a coefficient of thermal expansion similar to that of the stator.

13. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the

stator comprising an outer annual yoke carrying magnetic flux between a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, the stator teeth being mounted as mechanically separate parts at an outer annular member, **characterized in** that the outer annual yoke is situated inside the outer annular member.

14. An electric motor/generator according to claim 13, **characterized in** that the outer annual yoke comprises separate parts, which are retained in their position by the outer annular member.

15. An electric motor/generator according to claim 14, **characterized in** that the separate parts are the stator teeth.

16. An electric motor/generator according to claim 13, **characterized in** that each stator tooth is integrated with the adjacent part of the outer stator yoke.

17. An electric motor/generator according to claim 13, **characterized in** that each stator tooth has a main body extending generally in a radial direction and parts protruding from the main body forming parts of the outer annual yoke.

18. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the stator comprising an outer annual yoke and a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, the stator teeth being mounted as mechanically separate parts at an outer annular member, **characterized in** that the outer annular member and the stator teeth have such a shape that when the stator teeth are mounted inside the annular member they are retained in their position only by forces acting from the annular member inwards towards the axis.

19. An electric motor/generator according to claim 18, **characterized in** that the diameters of the inner annular surface of the outer annular member are a little smaller than the outer diameters of the assembly of the separate stator teeth when they are placed side by side before mounting inside the annular member and in the configuration to be mounted therein.

20. An electric motor/generator according to claim 18, **characterized in** that each stator tooth has lateral surfaces

which are engaged with the lateral surfaces of the two neighbouring stator teeth.

21. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the stator comprising an outer annual yoke and a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, the inner ends of said teeth being formed with pointed tooth shoulders extending circumferentially, adjacent shoulders are closely spaced apart to provide a narrow gap therebetween, the stator teeth being mounted as mechanically separate parts at an outer annular member, **characterized in** that each stator tooth has lateral surfaces which are engaged with the lateral surfaces of the two neighbouring stator teeth.

22. An electric motor/generator according to claim 21, **characterized in** that the lateral surfaces are located on parts of a tooth which protrude in generally circumferential directions from a main body of the tooth extending in a generally radial direction.

23. An electric motor/generator according to claim 22, **characterized in** that the cross-section area of a protruding part is at least essentially larger than half of the cross-section area of the radial main body.

24. An electric motor/generator according to claim 21, **characterized in** that the lateral surfaces are located at a radially outer places, adjacent to the outer annular member.

25. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the stator comprising an outer annual yoke and a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, **characterized in** devices maintaining the coil winding wire mechanically in place during and after winding, the devices being located at the axial sides of the stator poles, the devices having inner lateral surfaces facing and in engagement with an axial side of the stator pole tooth and outer lateral surfaces, over which the winding wire passes, the outer lateral surfaces having a smooth, at least partly curved shape adapted to locate the wire relative to the stator pole in such a way that

facilities the winding of coils so that the wires of the coils will run parallel to the axial direction of the stator poles along the axial length of the stator poles.

26. An electric motor/generator according to claim 25, **characterized in** that the inner lateral surfaces of the wire maintaining devices have a shape adapted to position the device at a correct place at the side of a tooth.

27. An electric motor/generator according to claim 25, **characterized in** that the outer lateral surfaces of the wire maintaining devices have a shape connecting smoothly to the other sides of a tooth.

28. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the stator comprising an outer annual yoke and a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, **characterized in** devices maintaining the coil winding wire mechanically in place during and after winding, the devices being located at the axial sides of the stator poles, the devices having inner lateral surfaces facing and in engagement with an axial side of the stator pole tooth and outer lateral surfaces, over which the winding wire passes, the inner lateral surfaces extending beyond the axial sides.

29. An electric motor/generator according to claim 28, **characterized in** that at portions of the inner lateral surfaces where they extend beyond the axial sides thin edges are provided adapted to follow the other sides of the stator poles.

30. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the stator comprising an outer annual yoke and a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, **characterized in** devices maintaining the coil winding wire during and after winding mechanically in place, the devices being located at the sides of the stator poles and having lateral wire supporting surfaces supporting the wires in directions towards and outwards from the rotor, the lateral wire supporting surfaces having a shape adapted to permit a geometrically dense or densely-packed winding of the wire.

31. An electric motor/generator according to claim 30, **characterized in** that the lateral wire supporting surfaces comprise an inner supporting surface located at angle of 30° in relation to the side of a tooth, on which an inner layer of the winding wire is wound, and an outer supporting surface distant from the rotor and located perpendicularly in relation to the same side of the tooth.

32. An electric motor/generator according to claim 30, **characterized in** that each wire maintaining device comprises a main body, having an inner lateral surface engaging an axial side of a teeth.

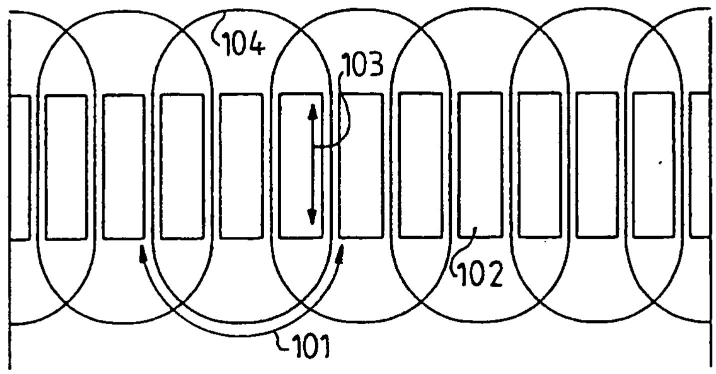
33. An electric motor/generator according to claim 32, **characterized in** that the main body carries generally axially extending flanges.

34. An electric motor/generator comprising a stator and a rotor, an annular air gap between the stator and the rotor, the stator comprising an outer annual yoke and a plurality of radially directed stator teeth, most or all stator teeth having a winding in the shape of a coil wound around one single stator tooth, **characterized in** devices maintaining the coil winding wire during and after winding mechanically in place, the devices having portions extending into a gap between the inner or front parts of neighbouring teeth, the portions being adapted to maintain the teeth at the same or a constant distance from each other for varying forces occurring when the motor is in operation.

35. An electric motor/generator according to one of the preceding claims, **characterized in** that the inner ends of said teeth facing the moving part of the motor/generator are formed with pointed tooth shoulders extending circumferentially, adjacent shoulders being closely spaced apart to provide a narrow gap therebetween.

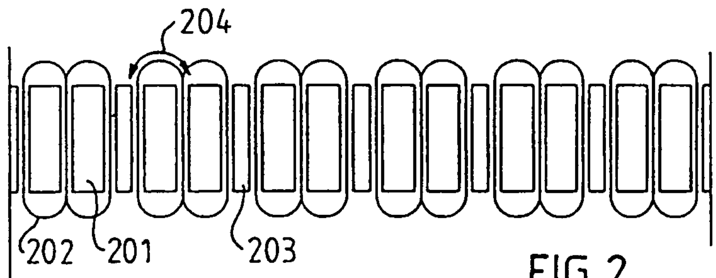
36. An electric motor/generator according to one of the preceding claims, **characterized in** that instead of a rotor a movable, generally flat or straight movable part is provided, the annular air gap being a gap extending generally straight, between generally flat surfaces of the stator and the movable part.

1/6



PRIOR ART

FIG. 1



PRIOR ART

FIG. 2

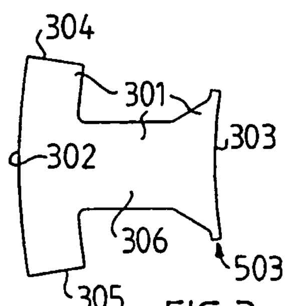


FIG. 3

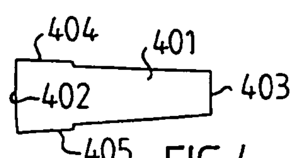


FIG. 4

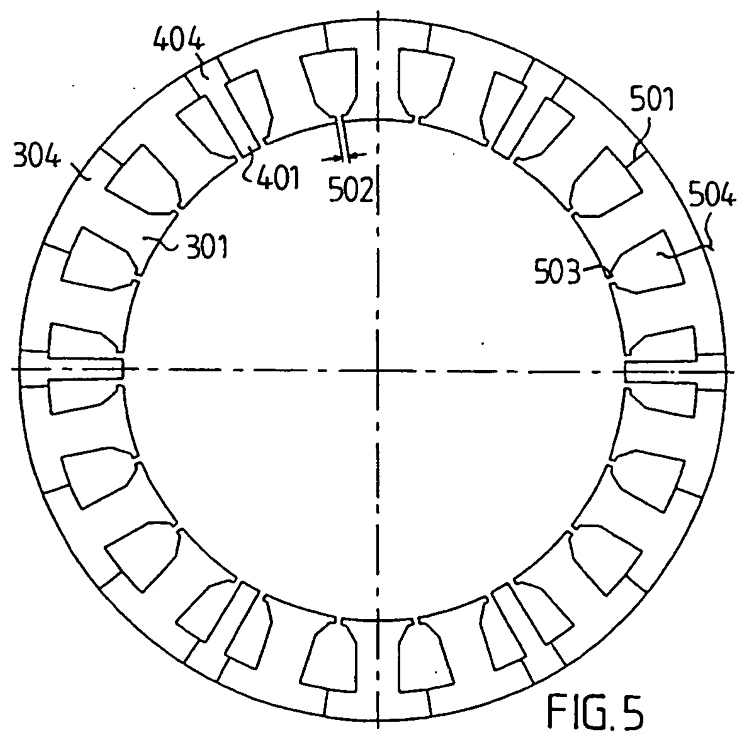


FIG. 5

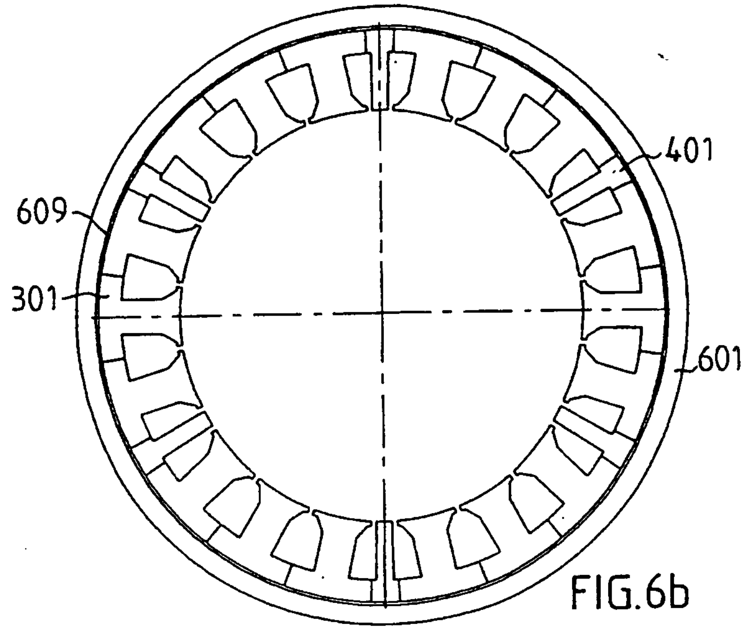


FIG.6b

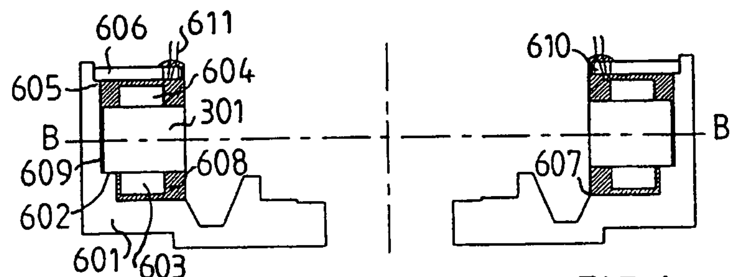


FIG.6a

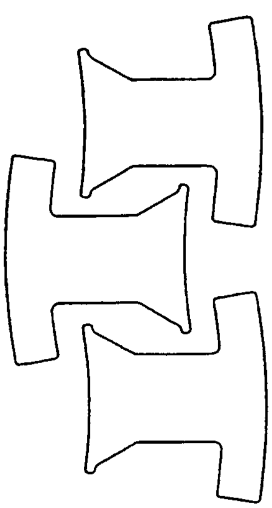


FIG.7

SUBSTITUTE SHEET

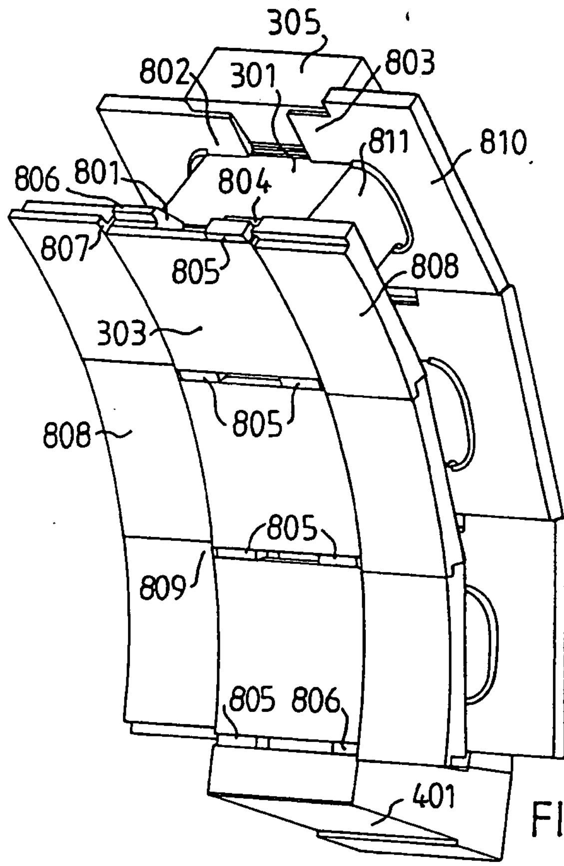


FIG.8

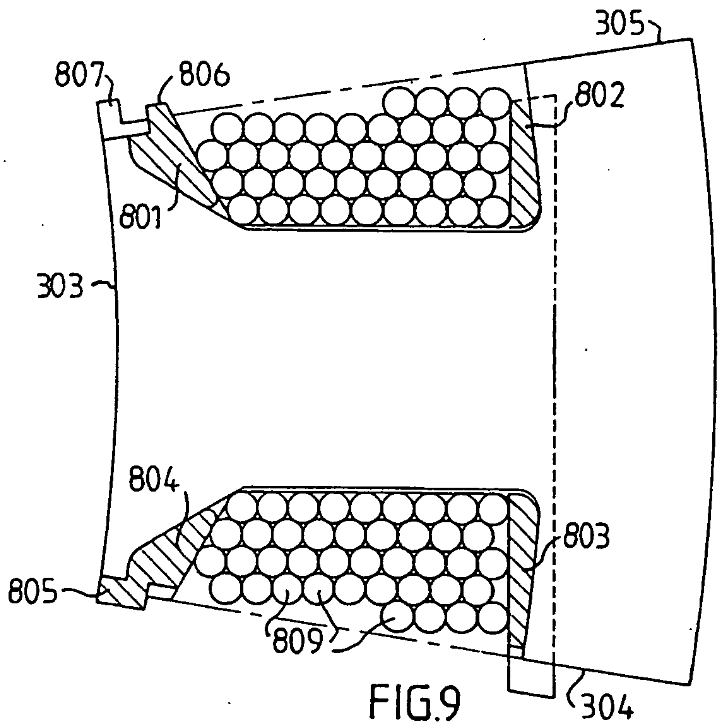


FIG.9

SUBSTITUTE SHEET

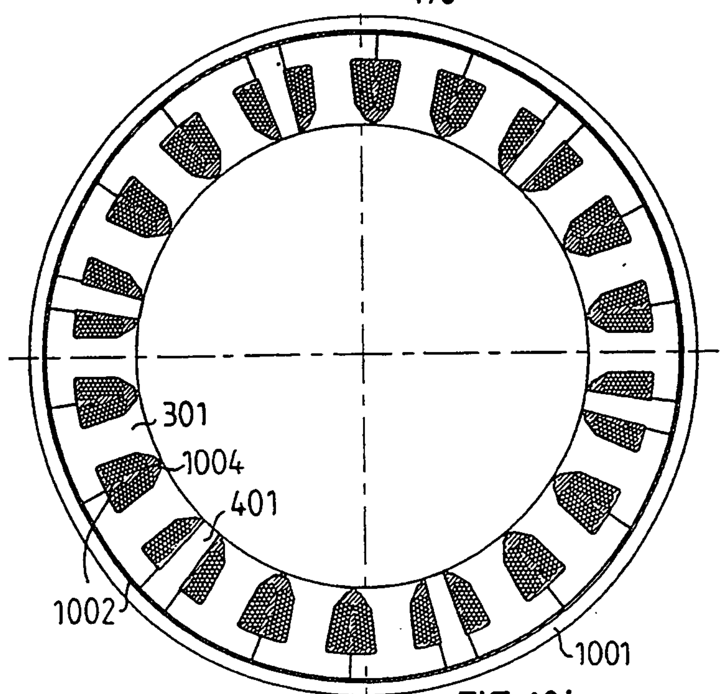


FIG.10b

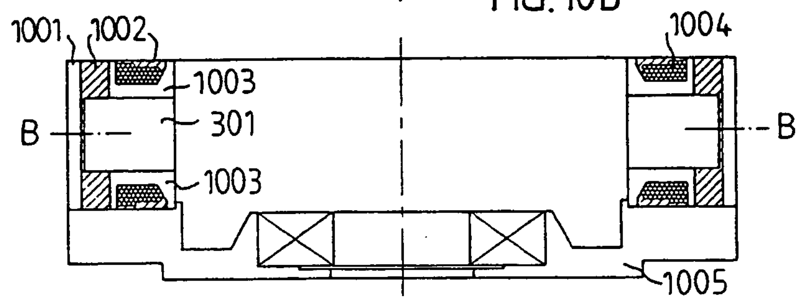


FIG.10a

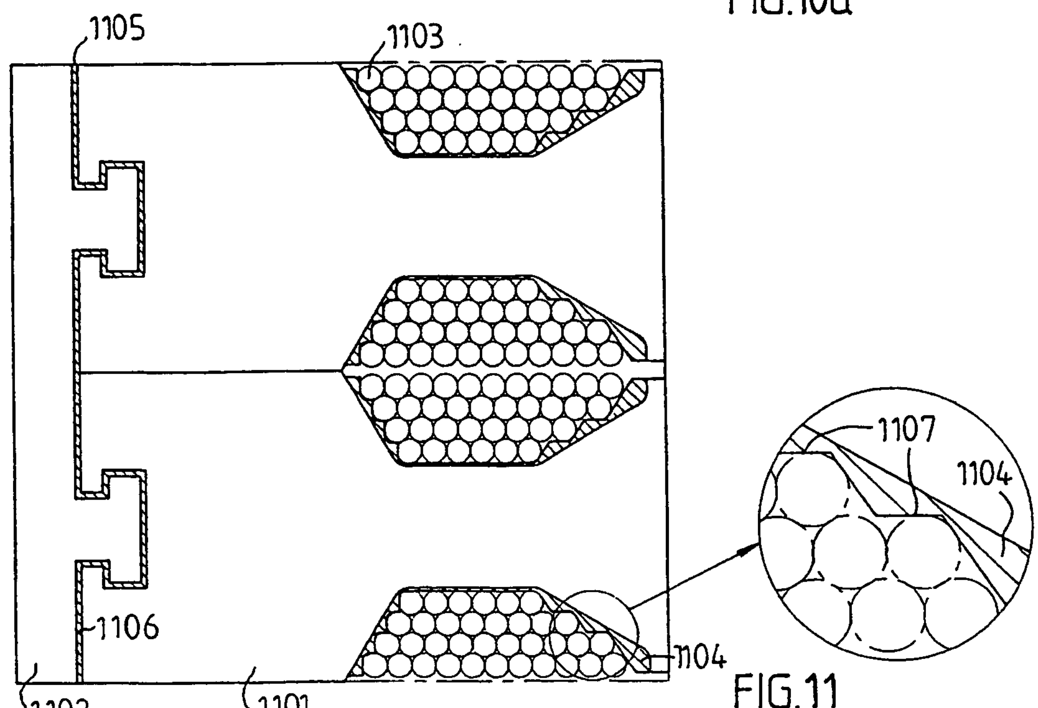


FIG.11

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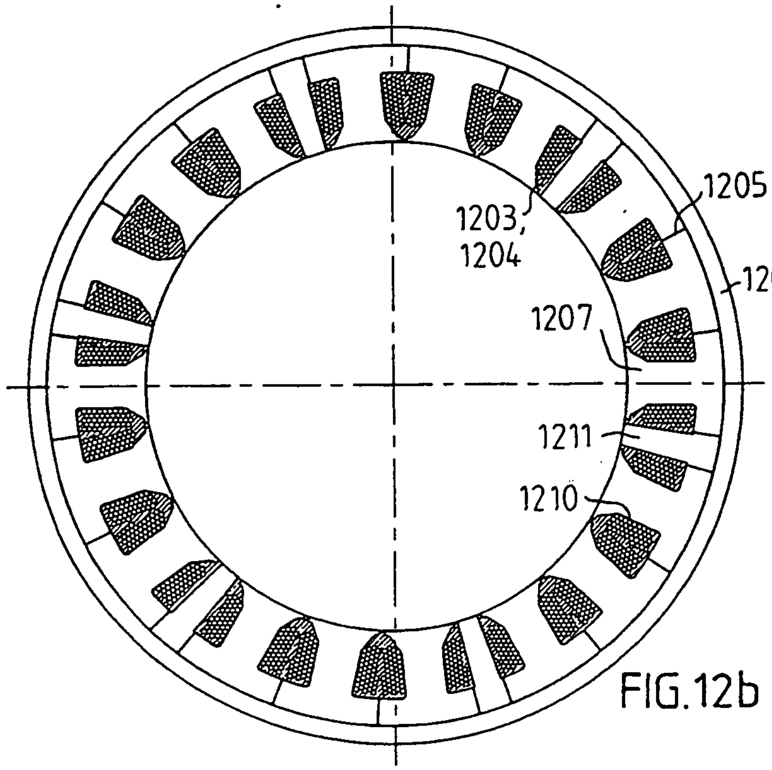

FIG.12b

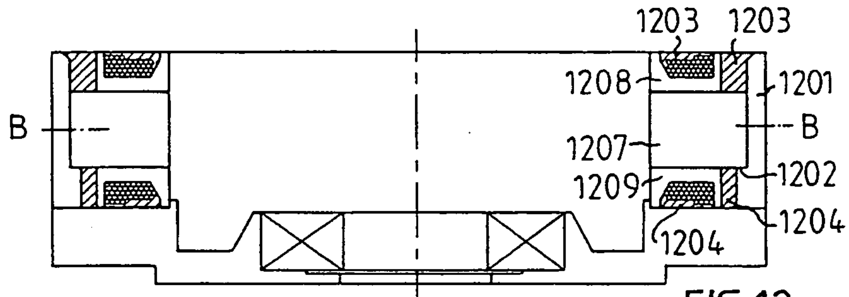

FIG.12a

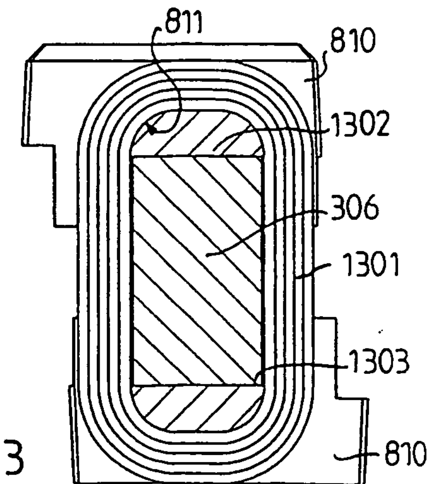

FIG.13

SUBSTITUTE SHEET

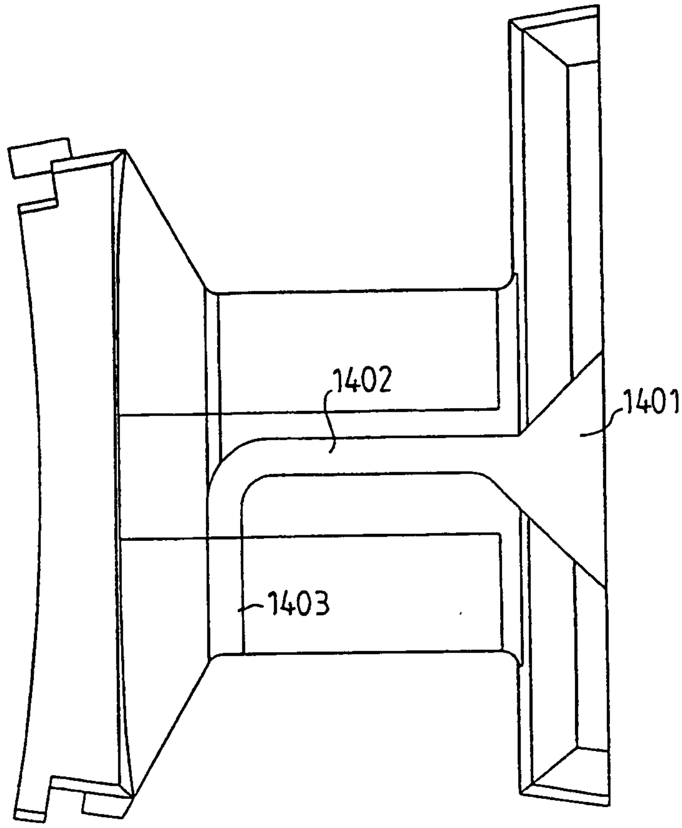

FIG. 14

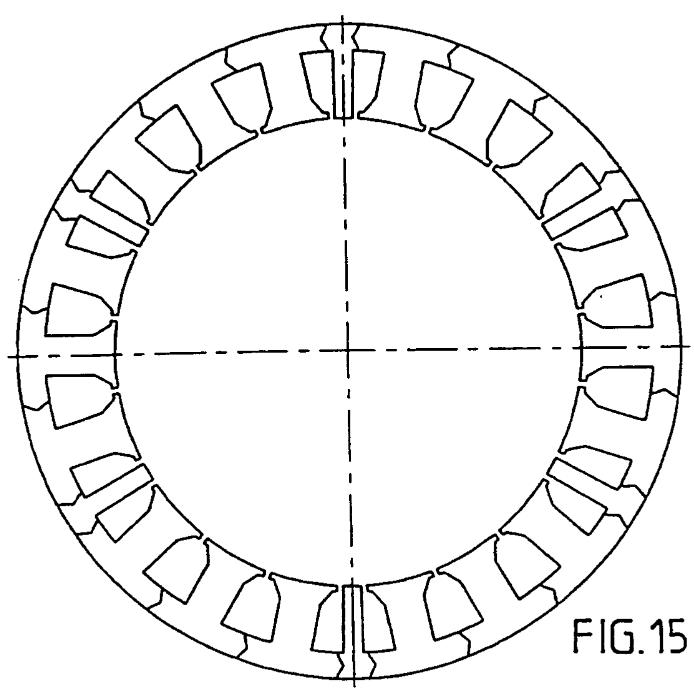

FIG.15

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/01026

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 1/16, H02K 3/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K, H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5212419 (FISHER ET AL.), 18 May 1993 (18.05.93), column 3, line 40 - column 4, line 16, figures 6,13, abstract --	1-24,35,36
X	WO, A1, 9004874 (NELCO HOLDINGS LIMITED), 3 May 1990 (03.05.90), figure 1, abstract --	1,4,11,35,36
A	Patent Abstracts of Japan, Vol 7,No 222, E-201, abstract of JP, A, 58-112430 (TOKYO SHIBAURA DENKI K.K.), 4 July 1983 (04.07.83) --	5
A	US, A, 3663850 (PHELON), 16 May 1972 (16.05.72), figure 3, abstract --	2,18-20

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"B" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 March 1995	05 -04- 1995
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Stefan Svahn Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/01026

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent's abstract, No 89-205250/28, week 8928, ABSTRACT OF SU, 1451805 (KOTLYAROV L V), 15 January 1989 (15.01.89) --	6-8,34
A	US, A, 2778964 (R.L. BALKE), 22 January 1957 (22.01.57), column 1, line 19 - line 25, figures 1-2 --	6,8
X	WO, A1, 8906874 (PRESTOLITE ELECTRIC INCORPORATED), 27 July 1989 (27.07.89), page 3, line 27 - page 4, line 4, figures 1-2, abstract	25-36
A		6-7
	--	
X	EP, A1, 0045125 (GEC-XPELAIR LIMITED), 3 February 1982 (03.02.82), figures 1-4, abstract	25-36
A		6-7
	--	
X	DE, C2, 2244806 (GENERAL ELECTRIC CO.), 15 May 1985 (15.05.85), column 1, line 39 - line 53, figure 2	25-36
A		6-7
	--	
X	GB, A, 2109168 (JOHNSON ELECTRIC INDUSTRIAL MANUFACTORY LIMITED), 25 May 1983 (25.05.83), figure 1, abstract	25-36
A		6-7
	--	
A	Patent Abstracts of Japan, Vol 14,No 507, E-998, abstract of JP, A, 2-209703 (MATSUSHITA ELECTRIC IND CO LTD), 21 August 1990 (21.08.90) --	7,30,31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/01026

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE, A1, 2316870 (STANDARD ELEKTRIK LORENZ AG), 27 March 1975 (27.03.75), figure 3, claims 1-2 --	7,30,31
A	DE, C2, 3712226 (DANFOSS A/S), 8 June 1989 (08.06.89), column 2, line 44 - line 47, figure 5 --	34
A	US, A, 3008786 (C.A. COSTELLO), 14 November 1961 (14.11.61), column 2, line 27 - line 34, figure 2 --	34
E,X	EP, A2, 0629034 (MATSUSHITA ELECTRIC INDUSTRIAL CO.LTD.), 14 December 1994 (14.12.94) --	1-36
X	EP, A2, 0405258 (ASEA BROWN BOVERI AKTIENGESELLSCHAFT), 2 January 1991 (02.01.91), figure 3, abstract -- --------	1,2,4-24,35, 36

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

(see extra sheet 210)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

The claims must be considered to represent two different inventive concepts and therefore lack unity of invention in the meaning of Rule 13.1.

Claims 1-24, and claims 35,36 when referring to these claims, define one invention relating to the magnetic circuit of a stator. The stator comprises sepatate stator teeth each including a segment of the stator yoke. These sepatate parts are kept together by an outer ring.

Claims 25-34,and claims 35,36 when referring to these claims, define another invention relating to the winding of an electric machine. The windings are kept in place during and after winding by devices attached to the stator.

These inventions may work well together, but since they are defined separately in the claims and sivce there is no technical relationship among these inventions involving one or more of the same or corresponding special technical features, these inventions are not so linked as to form a single general inventive concept (Rule 13.1, 13.2).

INTERNATIONAL SEARCH REPORT

Information on patent family members

25/02/95

International application No.
PCT/SE 94/01026

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US-A-	5212419	18/05/93	AU-A-	3433593	03/08/93
			CA-A-	2127557	22/07/93
			EP-A,A-	0620952	26/10/94
			WO-A-	9314552	22/07/93
WO-A1-	9004874	03/05/90	EP-A-	0394414	31/10/90
			GB-A-	2224399	02/05/90
			JP-T-	3501919	25/04/91
US-A-	3663850	16/05/72	US-A-	3727302	17/04/73
US-A-	2778964	22/01/57	NONE		
WO-A1-	8906874	27/07/89	AU-A-	3050389	11/08/89
			DE-D,T-	68914538	01/09/94
			EP-A,B-	0353285	07/02/90
			SE-T3-	0353285	
			JP-T-	2503262	04/10/90
			US-A-	4816710	28/03/89
EP-A1-	0045125	03/02/82	AU-A-	7318881	04/02/82
			GB-A-	2081027	10/02/82
DE-C2-	2244806	15/05/85	FR-A,B-	2153025	27/04/73
			GB-A-	1409721	15/10/75
			GB-A-	1409722	15/10/75
			US-A-	3780323	18/12/73
			US-A-	3861026	21/01/75
GB-A-	2109168	25/05/83	FR-A-	2511817	25/02/83
DE-A1-	2316870	27/03/75	BE-A-	813273	04/10/74
DE-C2-	3712226	08/06/89	FR-A-	2613884	14/10/88
			GB-A,B-	2203597	19/10/88
			JP-C-	1881659	21/10/94
			JP-A-	63265537	02/11/88
			SE-A-	8801004	11/10/88
			US-A-	4808872	28/02/89
US-A-	3008786	14/11/61	NONE		
EP-A2-	0629034	14/12/94	NONE		